EXTENDED DYNAMIC RESOURCE ALLOCATION

IN PACKET DATA TRANSFER

BACKGROUND OF THE INVENTION

5

Field of the Invention

This invention relates to multiple access communication systems and in particular it relates to dynamic resource allocation in time division multiple access systems.

10

Description of Related Art

In Multiple access wireless systems such as GSM, a number of mobile stations communicate with a network. The allocation of physical communication channels for use by the mobile

15 stations is fixed. A description of the GSM system may be found in The GSM System for Mobile Communications by M. Mouly and M. B. Pautet, published 1992 with the ISBN reference 2-9507190-0-7.

With the advent of packet data communications over Time

20 Division Multiple Access (TDMA) systems, more flexibility is required in the allocation of resources and in particular in the use of physical communication channels. For packet data transmissions in General Packet Radio Systems (GPRS) a number of Packet Data CHannels (PDCH) provide the physical

25 communication links. The time division is by frames of 4.615 ms duration and each frame has eight consecutive 0.577 ms slots. A description of the GPRS system may be found in (3GPP TS 43.064

v5.1.1).   The slots may be used for uplink or downlink communication.   Uplink communication is a transmission from the mobile station for reception by the network to which it is attached.   Reception by the mobile station of a transmission from the network is described as downlink.

In order to utilise most effectively the available bandwidth, access to channels can be allocated in response to changes in channel conditions, traffic loading, Quality of Service and subscription class.   Owing to the continually changing channel conditions and traffic loadings a method for dynamic allocation of the available channels is available.

The amounts of time that the mobile station receives downlink or transmits uplink may be varied and slots allocated accordingly.   The sequences of slots allocated for reception and transmission, the so-called multislot pattern is usually described in the form RXTY.   The allocated receive (R) slots being the number X and the allocated transmit slots (T) the number Y.

A number of multislot classes, one through to 45, is defined for GPRS operation and the maximum uplink (Tx) and downlink (Rx) slot allocations are specified for each class.

In a GPRS system, access to a shared channel is controlled by means of an Uplink Status Flag (USF) transmitted on the downlink to each communicating mobile station (MS). In GPRS two allocation methods are defined, which differ in the convention about which uplink slots are made available on receipt of a USF. The present invention relates to a particular allocation method,

in which an equal number "N" of PDCH's, a "PDCH" representing a pair of uplink and downlink slots corresponding to each other on a 1-1 basis, are allocated for potential use by the MS. The uplink slots available for actual use by a particular mobile station sharing the uplink channel are indicated in the USF. The USF is a data item capable of taking 8 values V0- V7, and allows uplink resources to be allocated amongst up to 8 mobiles where each mobile recognises one of these 8 values as 'valid', i.e. conferring exclusive use of resources to that mobile. A particular mobile station may recognise a different USF value on each of the slots assigned to that mobile station. In the case of the extended dynamic allocation method, for example, reception of a valid USF in the slot 2 of the present frame will indicate the actual availability for transmission of transmit slots 2…N in the next TDMA frame or group of frames, where N is the number of allocated PDCHs. Generally for a valid USF received at receiver slot n, transmission takes place in the next transmit frame at transmit slots n, n+1 et seq. to the allocated number of slots (N). For the extended dynamic allocation method as presently defined these allocated slots are always consecutive.

The mobile station is not able instantly to switch from a receive condition to a transmit condition or vice versa and the time allocated to these reconfigurations is known as turnaround time. It is also necessary for the mobile station, whilst in packet transfer mode, to perform neighbourhood cell measurements. The mobile station has continuously to monitor

all Broadcast Control Channel (BCCH) carriers as indicated by the BA(GPRS) list and the BCCH carrier of the serving cell. A received signal level measurement sample is taken in every TDMA frame, on at least one of the BCCH carriers. (3GPP TS 45.008v5

5   10.0). The turnaround and measurement times guaranteed by the network for a mobile station depend on the multislot class to which the mobile claims conformance (3GPP TS 45.002v5.9.0 Annex B).

The neighbour cell measurements are taken prior to

10 re-configuration from reception to transmission or prior to re-configuration from transmission to reception.

A mobile station operating in extended dynamic allocation mode presently must begin uplink transmission in the Tx timeslot corresponding to the Rx timeslot in which the first valid USF

15 is recognised. That is to say that there is a fixed relationship in the timing of the downlink allocation signalling and subsequent uplink transmission. Owing to the physical limitations of single transceiver mobile stations some desirable multislot configurations are not available for use.

20 These restrictions reduce the availability of slots for uplink transmissions thereby reducing the flow of data and the flexibility of response to changing conditions. There is a need therefore to provide a method with which to enable the use of those multislot configurations currently unavailable for

25 Extended Dynamic Allocation.

SUMMARY OF THE INVENTION

It is an object of this invention to reduce the restrictions affecting extended dynamic allocation with minimal effect on the existing prescript. This may be achieved

5 by altering the fixed relationship in the timing of the downlink allocation signalling and subsequent uplink transmission for certain classes of mobile station.

In accordance with the invention there is a method for controlling uplink packet data transmissions and a mobile

10 station operating in accordance with the method as set out in the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

15 An embodiment of the invention will now be described with reference to the accompanying figures in which:

Figure 1 illustrates the GPRS TDMA frame structure showing the numbering convention used for uplink (UL) and downlink (DL) timeslots;

20 Figure 2 illustrates a prior art 4 slot steady state allocation R1T4;

Figure 3 illustrates a 5 slot steady state allocation R1T5 prohibited in the prior art;

Figure 4 illustrates a 5 slot steady state allocation R1T5

25 enabled by the method of the present invention;

Figure 5 illustrates a shifted USF applied to a class 7 MS with 3 uplink slots allocated;

Figure 6 illustrates a class 7 MS with 2 uplink slots allocated;

Figure 7 is a flow diagram for the implementation of shifted USF in a mobile station;

5   Figure 8 illustrates a transition from one uplink slot to five uplink slots for a class 34 MS; and

Figure 9 illustrates a transition from four to five uplink slots for a class 34 MS.

10   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In this embodiment, the invention is applied to a GPRS wireless network operating in accordance with the standards applicable to multislot classes.

15   In figure 1 the GPRS TDMA frame structure is illustrated and shows the numbering convention used for uplink (Tx) and downlink (Rx) timeslots. It should be noted that in practice Tx may be advanced relative to Rx due to timing advance (TA), although this is not shown in the illustration. Thus in practice

20   the amount of time between the first Rx and first Tx of a frame may be reduced a fraction of a slot from the illustrated value of 3 slots due to timing advance.

Two successive TDMA frames are illustrated with downlink (DL) and uplink (UL) slots identified separately. The slot

25   positions within the first frame are shown by the numerals 0 through to 7 with the transmission and reception slots offset by a margin of three slots. This is in accordance with the

convention that that the first transmit frame in a TDMA lags the first receive frame by an offset of 3 (thus ordinary single slot GSM can be regarded as a particular case in which only slot 1 of transmit and receive is used).

5   The remaining figures conform to the illustration of figure 1 but the slot numbering has been removed for extra clarity. The shaded slots are those allocated for the particular states and the arrowed inserts indicate the applicable measurement and turnaround intervals. The hashed

10 slots indicate reception of a valid USF and the timeslot in which that USF is received. As mentioned above, constraints are imposed by the need to allow measurement and turnaround slots and the prescript for these in 3GPP TS 45.002 Annex B limits dynamic allocation as shown in table 1.

15

Table 1

Multislot class	Maximum number of slots			Minimum number of slots			
	Rx	Tx	Sum	T_{ta}	T_{tb}	T_{ra}	T_{rb}
7	3	3	4	3	1	3	1
34	5	5	6	2	1	1	1
39	5	5	6	2	1	1+to	1
45	6	6	7	1	1	1	to

T_{ta} is the time needed for the MS to perform adjacent cell signal

20   level measurement and get ready to transmit.

T_{tb} is the time needed for the MS to get ready to transmit

T_{ra} is the time needed for the MS to perform adjacent cell signal

        level measurement and get ready to receive.

T_{rb} is the time needed for the MS to get ready to receive

It should be noted that in practice the times T_{ta} and T_{tb} may

be reduced by a fraction of a slot due to timing advance.

t_0 is 31 symbol periods timing advance offset

5

With reference to figure 2, a steady state single downlink and 4 uplink slot allocation for a class 34 mobile station is illustrated. The turnaround and measurement periods for this class are shown in table 1 as Tra, Trb and Ttb each having one

10 slot and Tta having two slots. These periods can be accommodated for this allocation when a valid USF is received in time slot 0.

When the allocation of uplink slots extends to five, however, a constraint arises as indicated in the illustration

15 of figure 3 which is for a class 34 mobile station with an allocation of one downlink and five uplink slots.

The constraint occurs at the position indicated by 'A' because no time is allowed for the changeover from transmit to receive (Trb). In the downlink time slot 0 a valid USF is

20 received and the following two slots provide for Tta. In accordance with the invention, for this embodiment the mobile has uplink slots assigned in the usual way, through the use of USF_TN0...USF_TN7 Information Elements in Packet Uplink Assignment and Packet Timeslot Reconfigure messages. The

25 network sends the USF, however, for both first and second assigned timeslots on the downlink PDCH associated with the second assigned timeslot.

Considering by way of example a class 34 MS with an assignment of 5 uplink slots (TN0 – TN4) as discussed above where the network sends USF_TN0 on timeslot 1 rather than timeslot 0. This arrangement is illustrated in figure 4 where it can

5 be seen that slots marked 'B' and 'C' provide for turnaround times Tra and Trb respectively.

An allocation by the network of 4 uplink slots to the MS will be signalled by the sending of USF_TN1 on timeslot 1. The characters of the two signals USF_TN0 and USF_TN1 must differ

10 and must be distinguishable by the mobile station.

It is not necessary to add extra information elements to indicate when the Shifted USF mechanism is to be used, as it may be made implicit in the timeslot allocations for the particular multislot class of the mobile station. Therefore no

15 increase in signalling overhead would be required.

With reference to figure 5, another example of an allocation enabled by implementation of a shifted USF is illustrated in figure 5. The application is a class 7 MS with three uplink slots allocated. The USF on downlink slot 1

20 allocating the 3 uplink slots indicates that the first uplink slot available is uplink slot 0 rather than the usual slot 1. This provides for the Ttb and Tra periods (as required by table 1) and as indicated in figure 5 at D and E respectively. The allocation would not previously have been available for want

25 of a sufficient period for Tra.

The 2 slot allocation illustrated in figure 6 reverts to normal operation i.e. the USF is not shifted. There are no

physical constraints in normal allocations for this 2 slot arrangement of figure 6 and the standard USF in time slot 1 allocates uplink slots beginning with uplink slot number 1.

Alternatively it may be convenient to apply positive signalling of the shift in position of the uplink allocation and an implementation of a shifted USF in a mobile station operating extended dynamic allocation is illustrated in figure 7. It should be noted that the indication (2) in figure 7 may be explicit (i.e. extra signalling) or implicit (automatic for particular multislot class configuration). With reference to figure 7, the mobile station receives at 1 an assignment of uplink resources and USF's from the network. If at 2, an indication to use a shifted USF is detected then, for the first USF, the second downlink slot is monitored (3) otherwise the first downlink slot is monitored (4). In either case, when a valid USF has been received at 5 then uplink transmissions are initiated in the first uplink slot from the mobile station (6). When no valid USF has been received at 5 then the second downlink slot is monitored for a second USF at 7 and if valid (8) then uplink transmissions are initiated in the second uplink slot (9).

In the examples illustrated in figures 2 to 6 the allocations are steady state such that the allocations shown are maintained from frame to frame. The invention is not restricted to steady state allocations and may be applied also to control of uplink resources that change from one frame to another.

Examples of transitions are illustrated in figures 8 and 9. These figures each represent four consecutive frames but have been split for presentation.

Figure 8 illustrates the transition from one uplink slot
5   allocation to five uplink slots allocation, for a Class 34 mobile. The first (top) two frames show steady state operation with one slot and the next (bottom) two frames show the transitional frames. For this transition the slot location of the USF is changed.

10   Figure 9 illustrates the transition from four uplink slots to five uplink slots, for a Class 34 mobile. The first two frames show steady state operation with four slots and the next two frames show the transitional frames. For this transition the USF slot location is constant but the value of
15   the USF is changed.

In order to implement the invention in GPRS for example a table (Table 2) may be constructed for a Type 1 MS to allow extended dynamic allocation using the principles below:

In the case of extended dynamic allocation it is desirable
20   for the MS to be able to "transmit up to its physical slot limit"; specifically, the MS should be able to transmit the maximum number of slots possible according to the limitation of its multislot class, while continuing to receive and decode the USF value on exactly one slot and performing measurements. If it
25   is not possible to define a multislot configuration which permits the MS to "transmit up to its physical slot limit" using T_{ra}, but it would be possible by using T_{ta} , then T_{ta} shall be

used.

If it is not possible to define a multislot configuration for extended dynamic allocation which permits the MS to "transmit up to its physical slot limit" but it would be possible by using the shifted USF mechanism, then shifted USF shall be used. In this case T_{ra} will be used as first preference, but if this is not possible T_{ta} will be used as second preference.

Table 2

Medium access mode	No of Slots	T_{ra} shall apply	T_{ta} shall apply	Applicable Multislot classes	Note
Uplink, Ext. Dynamic	1-3	Yes	-	1-12, 19-45	
	4	No	Yes	33-34, 38-39, 43-45	2
	5	Yes	-	34, 39	5
	5	No	Yes	44-45	2,4
	6	No	Yes	45	5
Down + up, Ext. Dynamic	d+u = 2-4	Yes	-	1-12, 19-45	
	d+u = 5, d > 1	Yes	-	8-12, 19-45	
	d = 1, u = 4	No	Yes	30-45	2
	d+u = 6, d>1	Yes		30-45	2,3
	d = 1, u = 5	Yes		34,39	5
	d+u = 7, d>1	No	Yes	40-45	2,4
	d = 1, u = 6	No	Yes	45	5
Note 1	Normal measurements are not possible (see 3GPP TS 45.008).				
Note 2	Normal BSIC decoding is not possible (see 3GPP TS 45.008).				
Note 3	TA offset required for multislot classes 35-39.				
Note 4	TA offset required for multislot classes 40-45.				
Note 5	Shifted USF operation shall apply (see 3GPP TS 44.060)				